

# Ground Software

**Jeff Johnson**  
**Software Engineer**  
**NRL**  
**202-404-1228**  
**[jjohnson@sgss.com](mailto:jjohnson@sgss.com)**



# Top Level Requirements



- Provide Command, Control, and Telemetry Support for All FAME Integration and Test Configurations (SOTB, STB, Flight Controller EAGE, Spacecraft EAGE, ELSE, SATSIM)
- Provide Command, Control, and Telemetry Support for All FAME Operational Configurations (MOC, SOC)
- Provide Compatibility With NRL's Blossom Point (BP) Ground Station System Architecture
- Support a Dedicated 11.3 M Limited Motion Antenna System at BP
- Provide Automated Control of Ground Configurations Via an Extendible Scripting Language
- Support Telemetry Acquisition and Processing for a Continuous CCSDS Packetized Data Stream at the FAME Data Rates
- Forward Science Data Packets and Instrument SOH Packets to the SOC in Real-time
- Support Monitoring of the On-orbit FAME Observatory, Including Systems Status Analysis, Limit Checking, Out-of-limits Reporting and Trending Analysis
- Provide Telemetry Archive and Playback for Both Science Data and SOH Data
- Support Command Uplink and Verification Per CCSDS COP-1 Protocols
- Support Three Command Modes: Real-time, Ground Preplanned, and Onboard Scheduling Based on Uplinked Command Loads
- Support Verification of Command Execution, Analysis of Results, Investigation of Anomalies, and Response to Off-Nominal Situations
- Support Initiation of Safing Measures Whenever It Is Determined That a Critical Event Seriously Jeopardizes the Mission If It Were to Continue to Operate Beyond Defined and Acceptable Operating Limits
- Support Calculation of S/C Velocity Knowledge, Range, and Range Rate Data to 1 cm/sec



# Derived Requirements (1 of 4)



- **Telemetry**
  - Support CCSDS Downlink Decoding and Processing at the FAME Telemetry Rates
  - Provide Packetized and Stream Decommuation
  - Provide Limit Checking and Alarm Detection
  - Provide Time Tagging Support of Incoming Telemetry
  - Provide Engineering Unit and Discrete Conversion
  - Provide Raw and Engineering Converted Displays
  - Support Derived Telemetry Processing
  - Provide Telemetry to Application Software (Subscribe/Unsubscribe)
- **Commanding**
  - Support CCSDS Uplink Processing and Encoding at the FAME Commanding Rates
  - Support CCSDS (COP-1) Command Uplink Verification
  - Support Command Formatting
  - Support Command Release Time
  - Support Blocks of Commands
  - Support Restricted/locked Commands (Requiring Special Authorization)
  - Provide for User Defined Command Verification (Based on Vehicle Telemetry)
  - Provide the Ability to Inhibit Command Verification
  - Provide for Error/retry Processing
  - Provide a Command History



## Derived Requirements (2 of 4)



- **Memory Processing**
  - Provide for Flight Memory/table Loading, Dumping and Verification
  - Provide for Merging of Multiple Copies of Memories
  - Provide Notification of Download Status (Begin/in Progress/complete)
  - Provide Off-line Decommutation of Recorded Telemetry
  - Provide Comparison of Command Loads Versus Memory Dumps
  - Provide Results of the Memory Comparison to the Online System for Subsequence Loads
- **Archive/playback**
  - Record/playback All Telemetry and Commands With Time Tags
  - Record and Retrieve All Alarms, Alerts, and Operator Interaction With Time Tags
  - Provide the Ability to Inhibit Recording
  - Provide Tools to Analyze and Generate Reports/graphs From Recorded Data
  - Provide Tools to Analyze and Generate Reports/graphs Long Term Archived Data
  - Support Playback Concurrent With Active Data Collections
  - Provide Playback Control (Start, Stop, Pause, Resume, Rewind, Start Time, Stop Time, Speed)
  - Provide Searchable Logging of All Processing Errors and Warnings
  - Provide Tools to Compress Recording Files for Long-term Storage



## Derived Requirements (3 of 4)



- **General**
  - Provide Operator Messages (Pop-up/scrolling)
  - Provide Color Coded Alarms/alerts/info Messages to the Operator
  - Provide Alarm/alert/info Message Filtering
  - Provide Alpha-numeric and Graphical Displays
  - Provide Telemetry/commanding Reports and Trending
  - Support Printing of Alpha-numeric and Graphical Displays and Reports
  - Provide Health and Status Telemetry Displays Via an Internet Browser Interface
  - Provide Periodic on Line Statistics for All Processing
  - Support Processing on a LAN or WAN Using Various Processing Nodes
  - Support a Heterogeneous Network of Nodes for Off-line Analysis
  - Automatically Verify and Archive All Formal Test Results
- **Hardware Support**
  - Control All Ground System Hardware (GPIB, Serial, Enet, VME, Special Interface)
  - Collect and Process Ground Equipment Telemetry
- **Mission Unique Software**
  - Provide Test Data Generation and Validation Tools
  - Provide Software Required to Set and Maintain Satellite Time
  - Provide Software Required to Time Assign Telemetry to Within 1ms UTC



# Derived Requirements (4 of 4)



- **Software Development**
  - **Write Application Software in “C”**
  - **Write Application Scripts in csh, sh, tcl, or perl**
  - **Follow the FAME CM Plan Using a COTS CM Tool**
  - **Provide Maintainable Ground Software**
  - **Provide Testable Ground Software**
  - **Provide Extensible Ground Software**
  - **Provide Consistent Ground Software**



# Major Trade Studies



- **Space/Ground Interface**
  - **CCSDS Recommendations**
    - **Conventional Packet Telemetry and Telecommand Recommendations**
    - **Advanced Orbiting System (AOS) Recommendations**
    - **“Hybrid” Approach**
      - **AOS Recommendations for Telemetry**
      - **Conventional Recommendations for Commanding**
  - **Telemetry Format**
    - **Frame Size (Efficiency vs. Responsiveness)**
    - **Grade of Service (Efficiency vs. Error Protection)**
- **Reusable Software (COTS, GOTS, and NDI)**
  - **Core Spacecraft Control System Toolkits and Components**
  - **Command, Control and Telemetry Application Processing**
  - **Command and Telemetry Database Tools**
  - **Command-Response Spacecraft Simulation Tools**
  - **Web-based Telemetry Monitoring Components**
  - **Software Development Tools**



# Issues



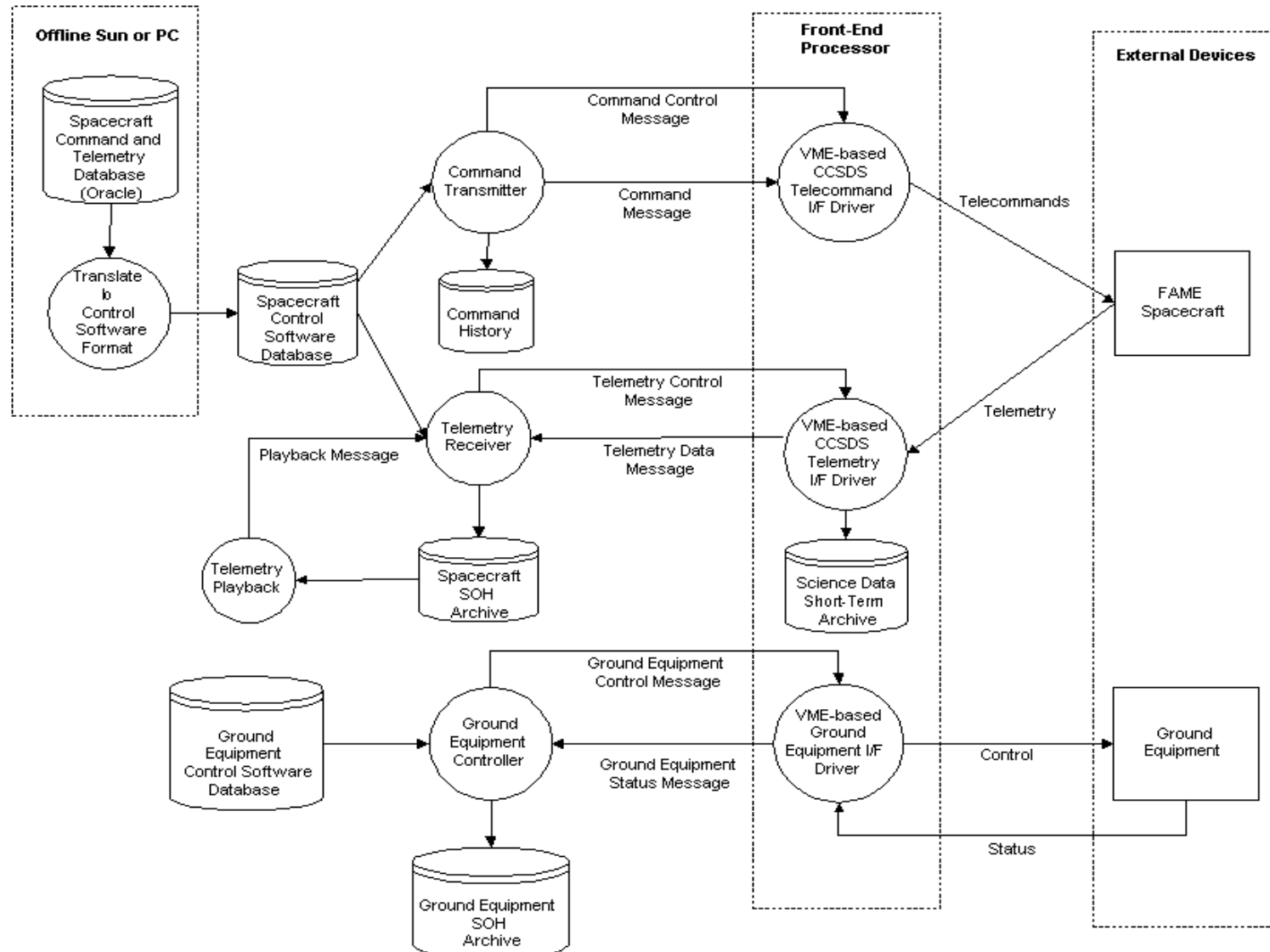
- **Closed-loop Simulation Requirements**
- **Final Selection of Core Spacecraft Control System Toolkit Per AOVC Evaluation (e.g. BP/Comet, Itos, OS/Comet)**
- **Roles and Responsibilities of BP Personnel for MOC Development**
  - **Antenna Monitoring and Control**
  - **Front-end Processor (FEP) Development and Interfaces**
- **Roles and Responsibilities of Science Team Personnel for SOC Development**
  - **Collection of Science Data**
    - **Does Some of the MOC Software Also Run at the SOC (e.g. Comet)?**
    - **Does the Science Data and Instrument SOH Data Get Transmitted to the Soc Using Sockets (or Comet Software Bus) With CCSDs Application Packets / Star Data Packets?**
  - **Storage Format of Science Data (Comet Recording Files?)**
  - **Processing Requirements for Science Data (Data Analysis)**
- **FEP for I&T Differs From the BP FEP Concept**





# Backup – 1

## FAME Spacecraft and Ground Equipment Control Design

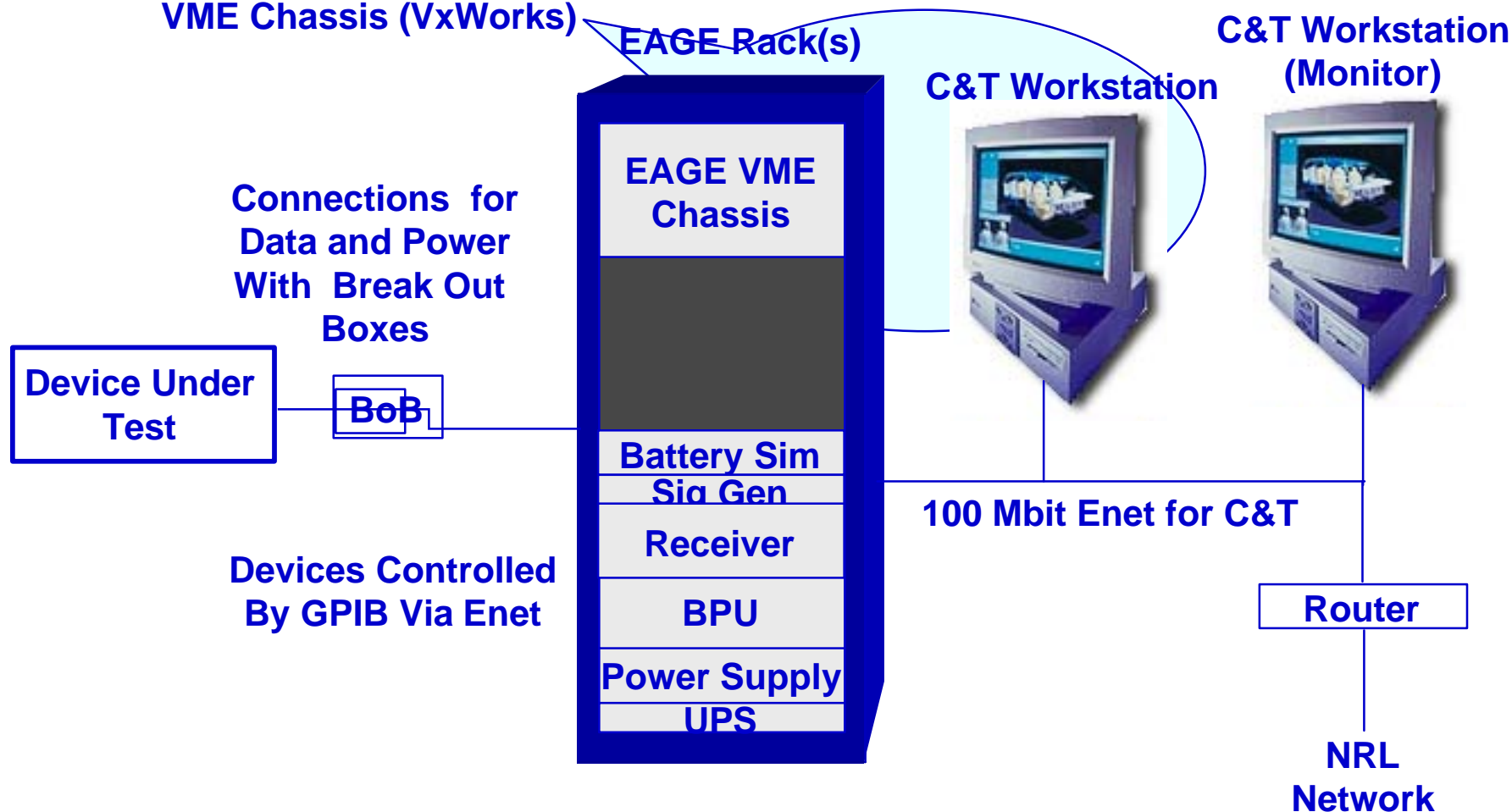




## Backup-2 Typical EAGE Design



Ground Software Is on  
Sun Workstation and  
VME Chassis (VxWorks)





# Backup – 3

## Typical EAGE Ground SW Design



1) The Software Bus Allows Us to Configure Components on Any Node in the LAN. The Telemetry and Commands May Come From/go to Any Interface (1553, Frame Sync, Serial)

2) Interface Tasks Handle All Hardware Specifics. Simulation Tasks Control the Interface Tasks Via The Software Bus. Simulations Are Independent From the Physical Interfaces.

